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As far as practicable the time of the seventy-fifth meridian, which is exactly five hours behind Greenwich time, is used in the text of the MONTHLY WEATHER REVIEW.

Barometric pressures, both at land stations and on ocean vessels, whether station pressures or sea-level pressures, are reduced, or assumed to be reduced, to standard gravity, as well as corrected for all instrumental peculiarities, so that they express pressure in the standard international system of measures, namely, by the height of an equivalent column of mercury at 32° Fahrenheit, under the standard force, i. e., apparent gravity at sea level and latitude 45°.

SPECIAL ARTICLES, NOTES, AND EXTRACTS.

SALTON SEA AND THE RAINFALL OF THE SOUTHWEST.

By Prof. ALFRED J. HENRY. Dated January 25, 1907.

There is a growing belief in the extreme Southwest, and possibly in other parts of the country, that the creation of Salton Sea is, in large part, responsible for the heavy rains of the last two years, not only in Arizona, but also in the Rocky Mountain States, and thence eastward over the plains. So strong is this belief that some persons have gone so far as to publicly advocate the maintenance of the present Salton Sea, notwithstanding the efforts now being put forth to shut off its supply.

Like other popular fallacies the present one doubtless arose from a careless consideration of the facts in the case, failure to consider whether the supposed cause was capable of producing the observed result, and finally, a misconception of the physical laws under which moisture in the atmosphere is condensed and precipitated as rain.

The facts, so far as they concern the purpose of this article, omitting all general details which are already familiar to the public, are as follows:

As early as October, 1904, there was some seepage water in the depression now known as Salton Sea, but no overflow water. In November, 1904, the Development Company completed a third intake on the Colorado River some miles below the first and second intakes in order to increase the supply of water for irrigation purposes. Soon thereafter a flood wave in the Colorado River scoured out the third intake so that it admitted more water than was needed. The surplus, which at times was very large, naturally sought the lowest part of the depression known as Salton Sink, and in the course of time Salton Sea was formed. It appears, however, that the increase in size of the so-called Salton Sea was gradual, and that it was not until October, 1905, that the total flow of the Colorado River was carried by various channels, mainly the Alamo and New rivers, into Salton Sink.

The rainfall of October, November, and December, 1904, in southern California and Arizona was not out of the ordinary, but beginning in January, 1905, and continuing thruout February, March, and April, an extraordinary amount of rain fell over a belt of country stretching from Florida to southern California, and the region of heavy rainfall also extended into eastern Colorado, eastern Wyoming, western South Dakota, western Nebraska, and western Kansas. With the coming of summer the locus of heavy rains shifted to the States of Nebraska, Kansas, South Dakota, and Oklahoma and Indian Territories. September and October were generally dry months, but in November heavy rains fell in Texas, and thence westward to Arizona. December was dry. In 1906 practically the whole of that great region west of the ninety-fifth meridian received more than the normal rainfall, the regions of greatest excess being central and western Kansas, central and western Nebraska, all of South Dakota, Wyoming, Colorado, Utah, and central and southern California. The excess in Arizona and New Mexico was not strikingly large.

Considering these facts in proper sequence it will be observed, first, that Salton Sea was not formed until *after the heavy rains of January, February, and March, 1905*, so that to ascribe the increased rainfall to Salton Sea would be to place the effect before the cause.

Admitting, for the sake of argument, that a body of water of the dimensions of the present Salton Sea existed before January, 1905, let us examine its probable effect on the rainfall of the Southwest. Its present dimensions are approximately 60 miles long, 8 miles broad, and say 25 feet deep on the average. These are rough estimates, but they will serve the purpose. The cubic contents would therefore be $60 \times 8 \times 0.0047 = 2.2$ cubic miles of water.

The normal annual rainfall of Arizona as determined by Section Director Jesunofsky is 11.75 inches. The rainfall for several years previous to 1905 was as follows:

1899	8.4 inches.	1903	9.9 inches.
1900	8.3 inches.	1904	9.8 inches.
1901	10.6 inches.	1905	26.6 inches.
1902	10.3 inches.		

From this statement it will be seen that the excess for 1905 was 14.85 inches, an amount more than equal to the normal annual rainfall. An inch of rainfall per square mile is equal to 72,516 short tons. As the area of the Territory is 113,956 square miles, the excess in tons for 1905 would be in round numbers $72,516 \times 14.85 \times 113,956 = 122,717,500,000$ short tons. Converting this amount into cubic miles of water for a comparison of its volume with that of Salton Sea, we have, as before, 1 inch of rainfall on a square mile weighs 72,516 tons. A cubic mile would be this weight $\times 5280 \times 12 = 4,594,613,760$

tons, or assuming that the temperature was somewhat above 39° F., say in round numbers 4,500,000,000 tons. The number of cubic miles of rain that fell in Arizona in excess of the average was, therefore, $\frac{122,717}{4500} = 27$. This quantity, as may be readily seen, is twelve times greater than the total volume of the Salton Sea. In other words, the total volume of the latter would barely suffice to produce one-twelfth of the surplus rain that fell in Arizona, to say nothing of the rainfall in adjoining regions. The total amount of water now in Salton Sea, if uniformly distributed in Arizona, would cover the Territory to the depth of about an inch and a quarter, or the equivalent of one good soaking rain. How then could the evaporation from Salton Sea, even if it amounted to 8 feet per annum, granting that it was all condensed and precipitated to earth, produce the enormous quantity of water that fell in Arizona in 1905?

As pointed out by Mr. Arthur P. Davis in the National Geographic Magazine, January, 1907, the advocates of the idea that Salton Sea has caused an increase in the rainfall of the Southwest seem to have ignored the presence of the Gulf of California, a body of water hundreds of times larger than Salton Sea, and distant from Arizona about the same number of miles. This body of water washes the shores of a region probably as arid as can be found on this continent. It has done so for centuries, yet no progressive changes from arid to humid conditions have been observed.

Mr. Davis has also pointed out that the disaster which caused the formation of Salton Sea has prevented the normal overflow of the lands in the Colorado Valley below Yuma. The areas of land in that region which would have been overflowed under normal conditions are nearer to Arizona and New Mexico, and of greater extent than Salton Sea, so that if evaporation alone causes rainfall, the tendency of the formation of Salton Sea would have been to reduce rather than increase the rainfall of Arizona and New Mexico.

The obvious deduction from the foregoing is that the Salton Sea is not responsible for the phenomenal rainfall of 1905 in Arizona.

THE INFLUENCE OF SMALL BODIES OF WATER ON LOCAL CLIMATE.

It is generally believed that small bodies of water have an appreciable influence on the local climate of contiguous land areas, but it is exceedingly difficult to distinguish between results which may be due to purely local causes and those which may be reasonably due to general causes.

The effect of a small body of water such as the Salton Sea on the climate of the surrounding territory may be recognized in two principal ways, first, in its equalizing effect on the temperature, and second, in the increased amount of water vapor thrown into the air by evaporation, since more water is evaporated from a water surface than from forests or fields. Owing to the fact that a water surface warms up much more slowly than a land surface and retains its heat much longer, the water surface will, in general, be warmer at night than the land, and cooler in the daytime. Thus there will be a tendency toward lower maximum temperatures and higher minimum temperatures in a narrow zone immediately surrounding the lake, but especially on the leeward shore.

The distinguishing characteristics of the climate of the Salton Sea region are those of the desert, viz, great heat and dryness. The annual mean temperature is about 77°; winter, 57°; spring 75°; summer, 97°, and autumn, 79° F. The maximum temperatures of the summer months range from 115° to 130° F., and the minimum temperatures of winter from 20° to 25° F. The annual precipitation is about 2.50 inches, most of which occurs in the cold months. The months of April, May, and June are practically rainless, but occasional showers fall in July, August, and September in about 30 per cent of the years. December and February are the months of greatest rain. In the winter snow may fall, but it rarely lies on the ground more than twenty-four hours; the average number of days in a year with 0.01 inch or more of precipitation is four. The winds of the Colorado Desert are mostly northwesterly in winter, and southeasterly to easterly in summer. In the cold season they flow through San Gorgonio Pass in the northwestern part of Riverside County, elevation about 2500 feet, as westerly winds, but are deflected somewhat toward the southeast by the San Bernardino Range which skirts the eastern and northern limits of the desert. Being descending winds and dry they are not favorable to precipitation. The cold winds are generally from north and east, while rain winds are from east and south. In summer the winds are not so stable as regards direction as in winter. While they are largely from the east and south there is at times a marked westerly component. No record of the diurnal change in the wind for the Salton Sea region is available.

At Yuma, Ariz., about ninety miles to the southeast, the winds in winter shift from northerly or northwesterly in the early hours of the morning, to northeast in the forenoon, and return to the same directions at night. During the latter part of April the northerly winds begin to give way to south and west winds; as the warm season progresses the northerly winds of winter shift to a southerly quarter. There is, however, a considerable easterly component at all seasons.

In the absence of instrumental records of wind velocity, little is definitely known of the force of the wind in the Colorado Desert. At Yuma, Ariz., high winds are infrequent, yet there is considerable motion in the air during the afternoon and evening hours. Such motion, however, is clearly discontinuous, and not calculated to transport air bodily out of the desert region, or to cause the importation of air of different density and moisture from adjoining regions. The particles of air that are set in motion by the winds of the daytime do not move continuously in the original direction, but are carried hither and thither by the light variable airs of the nighttime, and in some cases even in a direction contrary to that in which they traveled in the daytime. The annual hourly velocity of the wind at Yuma is nearly seven miles per hour, 3.1 meters per second, and the range is from an average velocity of three or four miles in the early morning hours to eight or ten miles in the afternoon. At Furnace Creek in Death Valley, an independent north-south basin, an average wind velocity of 9.9 miles per hour, 4.5 meters per second, was recorded from May to September, inclusive, but here the force of the wind is doubtless augmented by the local topography, and the results are not of general application. In general, it seems reasonable to assume that while there is more or less interchange of air between different portions of the desert, there is no permanent flow of the surface air in any direction except in winter, when the Plateau region is occupied by an area of high pressure. Then the winds blow from the north with much steadiness, so long as the Plateau high exists.

The moisture contents of the winds, especially at Yuma, are surprisingly constant. The north wind, since it descends from somewhat higher levels, is, in general, a dry wind, yet in the winter season the greatest relative humidity of the month may be experienced with a north wind. The moisture contents of the different winds for a winter month (February) and a summer month (August) are shown in the following table:

Vapor tension at Yuma, Ariz.

(An average of ten years.)

Direction.	February.	August.	Direction.	February.	August.
	Inches.	*Inches.*		*Inches.*	*Inches.*
North	0.16	0.57	South	0.21	0.60
Northeast	0.20	0.59	Southwest	0.22	0.55
East	0.20	0.67	West	0.21	0.56
Southeast	0.25	0.67	Northwest	0.20	0.54

The amount of aqueous vapor actually present in the air may be exprest either by the expansive force or pressure that it exerts or by its weight in grains in a cubic foot of space. In the above example it is stated in terms of its expansive force, or barometric pressure, in inches of mercury. Whether exprest in terms of weight or pressure, the amount of vapor actually present is sometimes called the absolute humidity. It is very important to distinguish between the absolute humidity and the relative humidity, sometimes referred to merely as the humidity. The relative humidity is the ratio of the amount of vapor actually present to that which might be present at the existing temperature if fully saturated: Example from Death Valley, June, 1891, temperature of dry bulb, 108° F., wet bulb, 68° F., whence is obtained from hygrometric tables: dew-point, 39° F., relative humidity, 10 per cent. A relative humidity of 10 per cent or less is not at all infrequent in desert regions. The observation quoted means, first, that in order to condense any of the moisture present into dew or rain the temperature would have to fall 69° (from 108° to 39° F.), or the amount of moisture then in the air would have to be increased ten fold. This point can not be emphasized too strongly. At the temperatures which exist in the Colorado Desert, and under the general conditions of aridity which prevail, the atmosphere takes up vapor as a sponge absorbs water. It should be remembered, moreover, that the capacity of the air for vapor is vastly greater at high than at low temperatures; the problem in the Southwest, therefore, so far as the production of rain is concerned, is not essentially one of increasing the vapor contents of the air but rather of diminishing the temperature to the point at which condensation takes place. There is sufficient moisture in the air to produce abundant precipitation if means of cooling it were at hand. The absolute humidity at Yuma is slightly greater than that of St. Louis, and only a little less than that of Vicksburg, both of which points have, in general, an abundance of rain and a so-called moist atmosphere.

The amount of vapor taken into the air over Salton Sea must be considerable in the course of a year, but to adduce definite and satisfactory proof that it has increased the rainfall is a very difficult problem. That it has increased the relative humidity in a slight measure, is undoubtedly true. Aqueous vapor in the absence of a strong wind circulation is diffused very slowly thruout the atmosphere. It is, therefore, improbable that any considerable portion of the local supply of vapor ever passes beyond the immediate confines of the desert. The writer knows of but one case where there is a reasonable presumption that the local evaporation has increased the rainfall, and the increase in this case amounts to but two or three inches annually over the immediate area whence the evaporation proceeds.

CHANGES OF LATITUDE AND CLIMATE.

It is well known that shortly after Mr. Chandler's convincing demonstration that the axis of rotation of the earth is changing its position within the earth in an irregular way not previously recognized, many astronomers suggested various explanations of the phenomenon in the search after the forces that brought it about. The memoir that seems to have had the greatest acceptance was that of Prof. Simon Newcomb, appearing in 1892, and showing in the first place that a periodic term of 306 days proper to a strictly rigid earth, as deduced by Euler and called the Eulerian period, would be increased if there were any elastic yielding of the earth under the great stresses to which it is subjected. Hough (1895) showed that an elastic steel globe would have a "free" period of 428 days in its axis of rotation as one of the terms in the nutation due to the action of the sun and moon on our globe. Newcomb also showed that a displacement of material on the earth's surface, such as the annual transportation of rain and snow between the poles and the equator, and possibly other meteorological phenomena, recurring year after year, would maintain such a variable annual disturbance of the regular 428-day term as to produce the change in latitude discovered by Chandler, since these phenomena produce a variable moment of inertia and are not symmetrical with regard to the earth's axis. The influences of changes of load have been most exhaustively studied by Prof. R. S. Woodward.

In a recent memoir by Prof. J. Larmor and Maj. F. Hills, published in the Monthly Notices of the British Royal Astronomical Society,[1] the authors have analyzed the movements of the North Pole, as most exactly determined since 1900 by Albrecht, and less exactly before that time. They have computed by graphical process from a map showing the path of the North Pole day by day, another map showing the departure from the 428-day period, thence the hodograph, and thence the torque that must be acting in order to produce that motion of the pole, whence we may infer something as to the displacements of atmospheric material, oceanic sediments, and continental material that must be taking place in order to produce this torque. By considering individual meridians the locations of the changes in the torques in the direction of the equator and of the meridians, respectively, can be determined approximately. If such changes are mainly due to displacements of surface material by any action of the atmosphere or solar heat they should show seasonal recurrences. Those which are not seasonal may prove to be due to subpermanent changes of masses of water or air as shown by changes in the level of the ocean or in the pressure of the atmosphere. Larmor and Hills show that a surface depression of one foot over a square mile of land, in latitude 45°, extending downward and diminishing to zero at a depth of 30 miles, that is to say, an average displacement of one foot down to 15 miles, would displace the polar axis thru a fraction of a second of arc represented by 3×10^{-13}. Sir G. Darwin showed that one per cent of the area of Africa moving ten feet vertically would alter the polar axis of a perfectly rigid globe by 0.2 seconds of arc. This direct effect upon the motion of the pole is so slight that an ordinary earthquake would have no influence, but observation seems to show that, within several years past, sharp curvatures in the movement of the pole appear to be, on the whole, concomitant with earthquakes. Possibly, therefore, earthquakes are promoted by those changes of the load carried by the earth that are the main cause of the irregular motion of the pole, so that the connection between earthquakes and change of latitude is a secondary one. Now a change of load that could cause an earthquake must, to a great extent, be due to transfer of ocean water, melting of polar ice, monsoonal flooding of large regions, like India, the deposition of mud in deltas, and other periodical matters that belong to meteorology. In fact the mere motion of ocean currents from the polar region, where water has but little angular momentum, to the middle latitudes where it has a great moment of inertia, must have an appreciable influence. The authors figure that if a mass of water representing a layer one foot deep over a region 4000 miles square were to move from the pole to latitude 45° it would displace the pole of rotation in the earth by something like two seconds of arc.

Of course any such movement is ordinarily counterbalanced by an equivalent circulation in the opposite direction; but frequently cases occur in which the equilibrium is not restored for six months or a year, as for instance in the case of an antarctic earthquake when 1000 square miles of ice floe is suddenly dislodged and floats northward, thus diminishing the moment of inertia of that continent until an equivalent amount of glacial snow and ice can again accumulate. A periodic change of this sort always occurs when the southeast trade breaks

[1] Presented at the meeting of the society in London, Nov. 9, 1906.